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Indian Standard

RECOMMENDATIONS FOR MAINTENANCE AND OPERATION OF PETROLEUM STORAGE TANKS

PART 1 PREPARATION OF TANK FOR SAFE ENTRY AND WORK

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Indian Standard

RECOMMENDATIONS FOR MAINTENANCE AND OPERATION OF PETROLEUM STORAGE TANKS

PART I PREPARATION OF TANK FOR SAFE ENTRY AND WORK

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Indian Standard

RECOMMENDATIONS FOR MAINTENANCE AND OPERATION OF PETROLEUM STORAGE TANKS

PART I PREPARATION OF TANK FOR SAFE ENTRY AND WORK

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 11 February 1981, after the draft finalized by the Structural Engineering Sectional Committee had been approved by the Structural and Metals Division Council and Civil Engineering Division Council.

0.2 Storage tanks in marketing installations of refineries are used to store crude oil, intermediates and refined products, gas, chemicals and water. These tanks are of different types and sizes, depending on their intended use.

0.3 With the revision and subsequent publication of IS : 803-1976* the committee decided to formulate a comprehensive Indian Standard, stipulating recommendations in regard to the maintenance and operation of petroleum storage tanks.

0.4 In this standard, provision regarding hazards encountered in the cleaning of petroleum tanks for the safe entry and methods and procedures for cleaning these tanks have been dealt with. The practices being followed in the country, in the maintenance of these tanks, have been kept in view while formulating this standard.

0.5 Part II of this standard stipulates provisions regarding inspection and inspection procedures for the maintenance of these tanks.

0.6 This standard stipulates precautions to be observed during the repair work of these tanks.

0.7 Assistance has been drawn from the following publications in the preparation of this standard:

i) API Pub 2015 Cleaning Petroleum Storage Tanks, American Petroleum Institute.

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*Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks (*first revision*).

ii) PSD 2207, Preparing Tank Bottoms for Hot Work, American Petroleum Institute, Petroleum Safety Data Sheet.

iii) PSD 2202 Dismantling and Disposing of Steel from Tanks which have Contained Leaded Gasoline. American Petroleum Institute, Petroleum Safty Data Sheet.

iv) Tank Cleaning Mandal — Lead Hazard Aspects of Cleaning Leaded Gasoline Tanks. Ethyle Corporation, USA.

v) Leaded Gasoline Tank Cleaning and Disposal of Sludge. The Associated Octel Company Ltd, England.

1. SCOPE

1.1 This standard (Part I) covers the preparatory work which shall be accomplished and the inspection and tests which shall be carried out to ensure that a petroleum storage tank has been properly gas-freed and is safe for opening, entry and carrying out necessary cleaning and other repair work. This standard also covers the methods and procedures for cleaning dismantling and disposal of discarded tanks.

1.1.1 This standard emphasises the necessity for thorough removal of harmful liquids, sediments and deposits and for freeing the tanks of flammable and inflammable toxic gases and preventing their re-entry in the tanks.

1.1.2 Only atmospheric storage tanks are considered in this standard

2. DEFINITIONS

2.1 Atmospheric Storage Tanks — Tanks which have been designed to operate with their gas and vapour spaces at internal pressures approximating atmospheric pressure.

2.2 Low Pressure Storage Tanks — Tanks which have been designed to operate with their gas or vapour spaces at pressure not exceeding 0·1 MPa (1 kgf/cm^2).

2.3 High Pressure Tanks — Tanks which have been designed to operate at pressures more than 0·1 MPa (1 kgf/cm^2). These tanks are more closely related to pressure vessels

2.4 Threshold Limit Value — It is the maximum permissible time-weighted average concentration in air over an eight hour day.

2.5 Leaded Gasoline — Leaded gasoline is a gasoline to which lead has been added, regardless of concentration. Gasoline with trace lead concentration (a few parts per million) would not, by this definition, be considered leaded gasoline.

2.6 Leaded Gasoline Storage Tank — A tank that has stored leaded gasoline but has not been thoroughly cleaned and made lead-hazard free.

2.7 Lead-Hazard Free Tank — A tank that has been cleaned to a point where all liquid, sludge and loose scale have been removed, is dry, has no leaking bottom, and the tank atmosphere contains not more than 100 micrograms of lead per cubic metre. Under these conditions, there shall be no occupational health hazard from the standpoint of lead. However, such a tank is not necessarily safe for ' hot work '.

2.8 Hot Work — ' Hot work ' means any work which involves welding, burning, soldering, brazing, sand blasting, chipping by spark producing tools, use of certain power driven tools, non-flameproof electrical equipment or equipment with internal combustion engines. It also includes any other work which is likely to produce sufficient heat, capable of igniting inflammable gases.

3. STATUTORY REQUIREMENTS

3.1 Statutory requirements as laid down by the Factory Act 1948 and Petroleum Act and rules framed thereunder regarding the cleaning/safe entry to the petroleum storage tanks for carrying out repair works etc and requirements relevant to the maintenance and operation of these tanks shall be complied with in addition to the provisions contained in this standard.

3.2 Any hot work shall require a safety certificate/fire permit from a competent authority of the installation. No hot work is to be started until the supervisor on the job has ensured that all precautions as stated in the sefety certificate have been taken as a clearance certificate obtained from the supervisor-in-charge of safety for that zone where the work is to be carried out.

3.3 Any cold work can be started after obtaining necessary clearance certificate from the supervisor-in-charge of safety for that zone where the work is to be carried out and after ensuring that all precautions stated in the clearance certificate have been taken.

4. TYPES OF ATMOSPHERIC STORAGE TANKS

4.1 Cone Roof Tanks — These tanks generally range in size up to 75 metres in diameter and 20 metres in height.

4.2 Umbrella Roof Tanks and Dome Roof Tanks — These tanks are modification of cone roof tanks. In dome roof tanks, the roof plates are usually formed with spherically curved sections, generally in such a way as to be self-supporting. The umbrella roof has segmental plates arched on meridian centre lines. These types of tanks are rarely built larger than 20 metres in diameter.

4.3 Floating Roof Tanks — These tanks are used to reduce filling and breathing losses to a minimum by eliminating or maintaining constant vapour space above the stored liquid.

SECTION I — PREPARATORY WORKS

5. GENERAL

5.1 This section discusses hazards which are encountered in the cleaning of tank which contained finished/unfinished petroleum products. These hazards shall, however, be controlled by proper planning, inspection and training of personnel for the job.

5.2 The hazards involved in preparing petroleum storage tanks for safe entry and work are:

i) Health hazards,
ii) Fire hazards, and
iii) Other hazards.

6. HEALTH HAZARDS

6.1 Condition of Atmosphere for Safe Breathing — Permissible Limits

6.1.1 Atmosphere within a petroleum storage tank may contain hydrocarbon vapours and other gases like hydrogen sulphide. For safe breathing, the maximum concentration of gasoline and similar hydrocarbon vapours in air shall not exceed 500 ppm (parts per million) for exposure an 8 hour day. This is equivalent to 5 percent of the lower flammable limit for these vapours.

6.1.1.1 Individuals vary in sensitivity to higher concentrations of the vapours. Physiologically, gasoline and similar hydrocarbon vapours have an anesthetic effect. In the first stages of over-exposure, human judgement is disturbed; later bewilderment and poor muscular co-ordination follows (the subject acts drunk). The person may loose functional control with longer or stronger exposures and may become unconscious unless rescued. At approximately 5000 ppm, dizziness may start in 5 minutes, loss of muscular control may start in 10 minutes and drunkness may be evident in 15 minutes. At 10,000 ppm, exposure for even a short period is dangerous and at 20 000 ppm exposure may be fatal within a short time.

6.1.1.2 Where aromatic hydrocarbons may be present as in gasoline vapours, the safe limit for 8 hours of exposure may be as low as 25 ppm for benzene vapours and 200 ppm for toluene or xylene vapours. It is necessary to use special testing techniques like gas spectrometry or gas — liquid chromatography when presence of aromatics is suspected.

6.1.2 *Permissible Limit for Hydrogen Sulphide*

6.1.2.1 Hydrogen sulphide (H_2S), a highly toxic gas, may be found in significant concentrations in and around tanks used in ' Sour Stocks ' services, such as crude oil, gas oil and even residues of bitumen, etc. It is a flammable gas, burns in air and is 1·189 times heavier than air. Its lower and upper flammable limits are appoximately 4·3 percent and 45 percent by volume in air respectively.

6.1.2.2 Hydrogen sulphide is a highly poisonous gas that attacks and paralyses the nerve centres of the heart and lungs. It has the following effects when present in air in the quantities stated:

Approx. Quantity in Air by Volume	*Effect*
10 ppm	— Safe to work in for up to 8 hours of exposure.
100 ppm	— The throat and eyes sting and burn and the sense of smell is lost in a few minutes.
500 ppm	— Causes dizziness and loss of consciousness. Breathing may stop in a few minutes.
700 ppm	— Causes unconsciousness very quickly and death will occur if not rescued promptly.
1000 ppm	— Unconsiousness at once and death will occur within minutes.

The toxity of hydrogen sulphide is very close to that of hydrogen cyanide and protective breathing equipment is essential when working in environments containing of hydrogen sulphide above 20 ppm.

6.1.3 *Deficiency in Oxygen*

6.1.3.1 Air within a tank which has been closed for an extended period, even though it might have been cleaned and emptied, may become deficient in oxygen because of the rusting of the metal of the tank.

6.1.3.2 No one shall be allowed to enter in a tank before it has been ventilated (*see* **6.1.4.1**) and ensured that a minimum of 19·5 percent oxygen is present inside the tank for work without respiratory protective equipment through which pure air is supplied.

6.1.4 *Ventilation*

6.1.4.1 When working without respiratory equipments, the ventilation shall be sufficient to ensure that workers will not be exposed to unsafe concentrations of flammable or toxic vapours or to deficiency in oxygen supply. To ensure the safety of the atmosphere, necessary gas tests shall be made by using appropriate combustible gas indicator, toxic gas indicator and oxygen indicator (portable meter) approved by the Statutory Authority. Knowledge of materials contained in the tank is necessary in order to determine the required test.

6.1.4.2 The supervisor shall be alert to the possibility of release of flammable or toxic vapours from sludge, scale, pockets or recesses in some of the internal structures.

6.2 Presence of Toxic Substances (Leaded Gasoline Tanks)

6.2.1 Entering a tank which contained leaded gasoline since the last thorough cleaning presents a hazard due to volatile and highly toxic organolead compounds in the gasoline vapours and in the sludge that may be sticking to the tank shell or settled at the bottom of the tank. These toxic lead compounds may get inhaled along with the vapours in the tank or absorbed through the skin by contact with liquids/sludge containing them.

6.2.2 It is usual to express the toxity of gas and vapours in terms of the Threshold Limit Value (TLV). For the volatile organd lead compounds present in leaded gasoline tanks, the TLV may be taken as 75 μg of lead per cubic metre. It is also not practicable to reduce the concentration of toxic vapours in the air inside such a tank to a safe level by any degree of ventilation, and thus it is necessary to wear protective respiratory equipment when entering such a tank. To prevent the absorption of toxic compounds through the skin by contact with liquid sludge, it is necessary for personnel to wear protective clothing in addition to the respiratory equipment.

6.2.2.1 *Lead-in-air-check* — The lead-in-air test shall be made after the tank has been cleaned to determine if it is free of lead hazard. No attempt shall be made to measure the concentration of lead vapours before or during tank cleaning, as such results could be misleading.

There is no known practical method for determining if lead hazard exists in a tank before it is cleaned. The absence or presence of odours is not a measure or indication of the presence of lead or gasoline vapours.

6.2.3 A tank which for sometime contained leaded gasoline and then used to store other products shall still be considered lead-hazardous, as the sludge in such a tank may contain lead for an indefinite period unless a thorough cleaning is carried out.

6.2.4 The minimum treatment to be carried out in order to make a tank free from lead hazard is:

i) Shot blasting down to the bare metal, or

ii) Heating the tank to a cherry-red heat in order to destroy the organic lead present.

6.2.5 Other hazards may arise from organic decomposition products of these organo-lead compounds or from the presence of inorganic forms of lead which have accumulated in sludge, in the water bottoms, or in the scales on the interior surface of the tank. The application of intense heat, such as in torch cutting and welding, also may evolve vapours from such lead compounds which are dangerous if inhaled. The scaling and scraping of dry internal surfaces of such a tank may contaminate the atmosphere with dust containing dangerous quantities of lead.

NOTE — An individual's susceptibility to above hazards is increased by lowered physical resistance resulting from poor health, fatigue or exhaustion.

6.2.6 *Precautions for Entering Tanks Used for Leaded Gasoline* — In view of the above, the following specific precautions shall be taken when entering tanks which have contained leaded gasoline in addition to other precautions for entering petroleum tanks:

i) Anyone who enters a tank that has not been thoroughly prepared shall wear respiratory protective equipment through which fresh air is continuously supplied under positive pressure to the face-piece covering the entire face, eyes, nose and mouth with eye-piece of splinterless glass. The equipment shall be continued to be worn until all material which may release lead vapours has been removed.

Long experience with hand-operated, blower-type equipment reveals that it may be used under a wide range of circumstances to furnish fresh air under positive pressure to the face-piece.

Respiratory protective equipment shall be in perfect condition equipment and the hose lines for masks of the blower-type shall be clean. If anyone wearing such equipment inside the tank detects an odour, such as that from gasoline, he shall leave the tank immediately, and shall not re-enter it until the cause has been determined and he has been provided with satisfactory equipment.

ii) Ordinary clothing shall not be worn for work in the tank. Personal clothing shall be left in a separate locker.

iii) In addition to the respiratory protective equipment, special clean clothing shall be worn from the skin outward. These include special overalls, shirts, underwear and socks. Outer clothing (overalls) shall preferably be white or light coloured. First-quality impermeable gloves and boots in perfect condition should also be worn. (Acid-proof rubber is an acceptable material).

iv) Freshly laundered clothing shall be worn at the beginning of the job and each day thereafter. At the end of the day such clothing shall be laundered. A bath shall be taken at the end of each day's work.

v) Clothing which has become soaked with sludge or gasoline shall be removed promptly. (Heavily contaminated clothing shall be burnt.) Before work is continued, a bath and a fresh change of clothing are necessary.

vi) Hose-mask sets (including hose lines), boots, gloves and tools shall be cleaned at the end of the each day's work.

vii) Workmen shall not carry tobacco or foodstuffs into the tank. The hands and face shall always be thoroughly washed with soap and water and a brush (making sure to brush the entire surface of the hands and under the nails) before handling such items. Finger nails shall be kept short and clean.

viii) Fingers in no circumstances shall be put into the mouth, while working in the tank.

ix) Anyone entering the tank shall pass medical fitness test. Personnel suffering from any nervous or respiratory trouble or any other clinical desease shall not be allowed to perform such work.

x) Workmen shall be allowed to enter the tank only under the observation of another person who remains outside, is provided with protective clothing and has a self-contained breathing apparatus ready.

xi) The period for which workmen are allowed to work inside a tank shall never exceed $1\frac{1}{2}$ hours without a break of $\frac{1}{2}$ hour in the open air.

xii) Sludge, scale, etc., shall not be allowed to remain in the tank longer than necessary and shall be removed from the tank in a wet state. It shall be noted that sludge is dangerous even when outside the tank and shall be treated and disposed of (*see* **6.3**).

xiii) Even after removal of sludge and scale, sufficient organo-lead derivatives remain absorbed on the sides and bottom of the tank to produce a toxic atmosphere and, therefore, the foregoing precautions shall be followed during subsequent inspections or repair work.

The generally accepted practice is to completely shot blast the entire internals of the tank and de-contaminate and dispose of the grit/shots along with the scale/sludge in the manner indicated under **15.2** and **18**. After this operation, that is complete cleaning by shot blasting, the tank may be considered free from lead hazards, and repair work carried out as for other petroleum tanks.

xiv) *Precautions for repairmen working inside a tank* — The following applies if the tank has been thoroughly cleaned, ventilated, tested and declared lead-hazards free:

Cold Work — It may be performed without additional preparation and without protective equipment. However, if dust is perceptive, appropriate respiratory equipment shall be used.

Hot work — Fresh air respiratory equipment shall be worn during welding or flame-cutting the tank bottom plates and the first shell ring. If the tank has a leaking bottom, additional caution shall be exercised because sludge and gasoline may be trapped underneath the tank bottom, thus presenting both a lead and an explosion hazard. If the heated area is above the first shell ring, hot work may be performed without protective equipment if it (the heated area) is first wire brushed or sandblasted to remove all particles that may retain lead. If the area is not cleaned down to bare metal, repairmen shall use fresh air respiratory equipment or a welder's facepiece designed for use with a hose mask through which fresh air is supplied (*see* **6.3.1.2**).

6.3 Precautions While Handling Leaded Gasoline Scale and Sludge

6.3.1 The toxic hazard presented by leaded gasoline scale and sludge is principally that of volatile organic lead vapour in air. Extensive data from a wide range of representative sludges monitored in open air directly above and downwind of the sludge has, however, shown that lead-in-air levels are low and only occasionally exceed the TLV. Adequate protection against this hazard shall be provided by appropriate protective clothing (as for tank cleaning) and canister respirators during all open air sludge handling operations (canister respirators shall remain 500 c.c. of activated carbon and specially approved for protection against tatraethyl lead. These shall be replaced after 100 hours aggregated use. Canisters shall be approved by competent authority).

6.3.1.1 While handling sludge outside the tank, PVC or neoprene or cotton overalls, boots and PVC gloves and a canister respirator shall be used.

6.3.1.2 The face-piece of the canister shall be a white rubber full face-piece with side vision window and shall be provided with neck strap, preferably of PVC rubber or terylene to keep it at chest level while temporarily removed. It shall be connected by a white rubber tube to the canister worn at side or back and shall have suitable arrangements for inhalation and exhalation. A face-piece shall be approved by the competent authority.

7. FIRE HAZARDS

7.1 Hydrocarbon Vapours

7.1.1 Fuel (in vapour form), air (oxygen) and ignition temperature are necessary for combustion, which shall occur only if all the three are present at appropriate levels. With regard to petroleum vapours, such as gasoline, theoretically, if the vapour content by volume is below one percent (lower flammable limit) with 99 percent air, or above 7 percent (upper flammable limit), the mixture shall be either too lean or too rich to burn.

7.1.2 In practice, when tank is prepared for hot work, it is necessary to remove all flammable or combustible liquids and to purge flammable vapours one to such an extent that the atmosphere contains muchless than approximately one percent vapour. In order to secure an adequate factor of safety, if the vapour content is known to be uniform at approximately 14 to 20 percent of the lower flammable limit, that is zero mark of the scale of the combustible gas indicator, it may be considered safe from fire or explosion. (From a comparable health effect standpoint, however, one percent lower flammable limit is equivalent to 10,000 ppm which is much higher than what can be tolerated for safe breathing even for a short period.)

7.1.3 Flammable mixtures may be ignited by open flames or by sparks from electrical tools/electrical fixtures which are not explosion-proof or from worn or defective electrical extension cords. In certain instances, mixtures may also be ignited by lightening and by sparks from the discharge of static electricity which have accumulated on the surfaces of liquids

7.2 Pyrophoric Iron

7.2.1 Another source of ignition is sometimes present in the tanks used for the storage of high sulphur or so called ' sour stocks '. Iron-polysulphide deposits may form when sulphur or sulphur compounds come in contact with the iron of storage tanks. Some of the iron polysulphide may be of the pyrophoric type. In equipment in which air can enter, iron sulphide normally is oxidized to iron oxide. In gas-blanketed tanks, where little or no air is present, great quantities of the sulphide may be formed. If such tanks were to be purged with the air in preparation for entry, the vapour space in the equipment would pass through the flammable range at some stage of the purging. At the same time, the pyrophoric iron sulphide shall be exposed to the same air and might start burning spontaneously. This may serve as source of ignition and cause flammable atmosphere in the tank to ignite or explode. Hence, special precautions are required to be taken throughout the gas freeing of such tanks so that:

i) Entry of air into the tank is prevented as far as possible until all interior surfaces have been wetted, and

ii) The interior surfaces of the tank are kept wet until the tank is gas-free.

7.3 Static Electricity

7.3.1 Use of high speed water jets for washing down the sludge or introducing water at high speed into the cone roof tanks for floating of remaining oil may generate static electricity and result in creation of high charge densities leading to possible discharges. These incendiary practices may not, therefore be considered safe, especially in case of cone roof tanks containing crude oil, gas oil or lighter fractions. Water may, however be introduced in cone roof tanks safely at a velocity of less than 1 metre/sec.

7.3.2 The geometrical shape of a floating roof tank with the roof resting on its legs set at a height of 2 metres, however, renders the situation safe and permits the introduction of water at velocities higher than 1 metre/sec without creating the hazard of static electricity. Water velocity may be gradually increased to 3 metre/sec after the end of the of pipe gets fully submerged in water.

7.3.3 The hazard of static electricity is also present where steam is used for gas-freeing of tanks. Though the charges left on the steam nozzle may be controlled by proper bonding, the charges left in the steam after it left the nozzle may collect on metallic objects inside the tank which are insulated from the ground. Sparks may then occur between a charged object and a grounded object. (The somewhat prevalent idea of spark discharges within the steam clouds themselves has not yet been substantiated.)

8. OTHER HAZARDS

8.1 Other hazards include physical hazards such as slipping, falling of objects, falling from or through the roof of a tank, improper scaffolding, etc.

SECTION II — CLEANING METHODS AND PROCEDURES

9. TANK CLEANING OPERATIONS

9.1 Tank-cleaning operations involve the following major steps:

- i) Preliminary preparations, including external inspection of tank and a survey of the surrounding area; training and indoctrination of the crew; and inspection of equipment.
- ii) Controlling sources of ignition.
- iii) Emptying the tank by pumping and floating, and blanking-off the tank after oil has been removed as far as practicable.
- iv) Vapour-freeing the tank.
- v) Testing the tank for hydrocarbon vapour and toxic gas.
- vi) Opening the tank and removal and disposal of sludge.

10. PREPARATION FOR CLEANING

10.1 The supervisor who is to handle tank cleaning operations shall review all the probable hazards involved and he shall keep his men informed and instructed with particular emphasis on leaded tanks. The work permit system shall be rigidly followed.

10.1.1 It is a very important part of the supervisor's duty that his men always observe safety precautions, and in order to do this he shall make frequent visits to site during cleaning operations. This would avoid personnel to take short cuts, which may result in accidents. In addition, random checks shall be made by other persons such as shifts superintendent, safety engineer and process and maintenance managers.

10.1.2 The supervisor shall also determine the type of crude oil or unfinished/finished petroleum product stored in the tank, since the last thorough cleaning, as well as the indicated amount of sludge within the tank and the physical condition of the tank itself. A survey of the surrounding area shall be made to determine whether it is safe to perform cleaning operations.

10.2 Only work essential to vapour removal shall be performed before the tank has been vapour-freed and before sludge has been removed.

10.3 Equipment including personal protective equipment that is boots, gloves, breathing apparatus, canister masks, etc to be used for tank cleaning operations shall be inspected to ensure that these are in perfect condition and adequate for the purpose intended. (Canister-type masks shall be used outside the tank only. They provide protection for only a relatively short period. They do not protect properly against high vapour concentration nor against oxygen deficiency.)

11. CONTROL OF SOURCES OF IGNITION

11.1 It shall be noted that gas-freeing of tanks will liberate considerable quantities of inflammable and possibly toxic vapours and, under certain climatic conditions, these may travel long distances and extend the danger area to more than 45 to 50 metres from the source of vapour. A careful watch shall be kept during gas-freeing operations against these vapours approaching possible sources of ignition.

11.2 The area within 15 metres of the tank shell shall be kept free of all sources of ignition from the time tank cleaning starts until the tank is gas-free and the sludge has been removed. Signs shall be posted warning that sources of ignition shall be kept out of the area and in the vicinity not other job shall be done which may introduce an additional source of ignition.

11.3 Portable lights, electric motors and switch gears used outside the tank in the path of possible vapour travel shall be of the explosion proof types and shall be connected to explosion proof extension cords equipped with approved connectors. Such equipment, when used, shall be thoroughly inspected to be sure that it will not be a source of ignition

12. EMPTYING AND BLANKING OFF THE TANK

12.1 Before the tank is opened, all the oil shall be pumped or drained off, to the lowest possible level, through the lowest tank connection. Temperature permitting, water shall be added through an existing piping connection, if possible (not through a roof opening), to float any remaining products out of low spots and the contents pumped or drained off. This procedure may be repeated several times, if necessary.

12.2 After residual oil has been removed as far as practicable, all pipelines connected to the tank including steam, foam and similar lines shall be blanked off to prevent the entrance of oil vapours or liquids to the tank through such lines (when blanking off cannot be done, it is advisable to fill the dead ends with water or to test them individually). In addition, valves in such lines outside the fire walls and nearest to the tank shall be closed.

12.3 Blanking off is accomplished by first closing all the valves nearest to the tank, then breaking the connections and placing spades in all the lines. Before the spades are installed, all lines which enter the tank shall be drained or flushed.

12.4 Spades shall be of sufficient strength and thickness to withstand the maximum pressure which might be exerted against the line.

12.5 When it is necessary for workmen to go on to a tank roof, planks shall be used to distribute their weight over a larger surface if the roof plates have become thin.

13. VAPOUR-FREEING THE TANK

13.1 Vapour-freeing a tank is a critical operation, and the area shall be vacated except when an occasional vapour test is necessary to check the progress of vapour freeing.

NOTE — Vapour-freeing, in the sense used herein, implies the complete replacement, with fresh air, of the hydrocarbon vapours which are generally present inside a tank used for storing petroleum products.

13.2 To ensure maximum diffusion of vapours in the surrounding area and reduce the possibility of formation of flammable mixture at ground level, it may be necessary to exhaust vapours through the roof manholes. This, however, shall involve installing the eductor on the tank roof with the suction hoses extending into the tank and air/steam supply hoses being taken right up to the roof. All this implies too much working on the roof of a tank which is empty but not gas free and may give rise to a spark caused by striking of metal parts, In order to avoid an explosion due to such a spark, forced ventilation by an air/steam driven eductor attached to one of the manholes in the lower part of the tank wall is recommended. This will purge air entering the tank through manholes on the roof. This is a quick and safe method to make a tank vapour-free, but requires care to be taken to control the entry of personnel into the area since during this process considerable quantities of vapours shall be discharged into the atmosphere around the tank. All persons entering the area shall wear protective respiratory equipment. Ordinary (natural) ventilation may be used to remove tank vapours. All roof and shell manhole covers should be removed in that order, so that air may circulate freely through the tank.

13.3 Special attention shall be given to the vapour-freeing of tanks which previously contained sour stocks because of the possible presence of pyrophoric deposits. These deposits on all interior surfaces of the tank shall be kept wet with water in the following manner :

i) In floating roof tanks, water may be filled up to the roof level without permitting the roof to float and with dip hatch open. Not only this will displace the vapours, but also we tall the pyrophoric deposit present on the interior surfaces.

ii) The inside surfaces of cone roof tanks may be wetted by introducing about one tonne/hour of steam in the upper part of the tank for about one hour by direct connections to one or more roof vent fittings. Subsequent to one hour of steaming the roof manholes may be opened and steaming continued for further 23 hours, after which forced ventilation may be started by connecting the eductor to the bottom manhole (men engaged in the operation of removing manhole cover and fitting eductor must wear breathing apparatus). Steaming shall be continued during the time of forced ventilation.

13.4 Steam ventilation may prove advantageous in some cases. However, the use of steam introduces some special hazards. To be effective, it must be introduced at a rate high enough to raise the temperature inside the tank to at least 77°C (170°F). Often, there is not sufficient steam available to do this during cold weather or if the tank is large. If the temperature in the tank reaches equilibrium below 77°C (170°F), the steam will condense as fast as it is introduced and no more vapour will be expelled. However, to keep the steaming operation safe, it should be ensured that steam temperature is lower than the relevant auto-ignition temperature of the tank contents. The flow of steam into the tank may generate static electricity (*see* **7.3.3**) which can cause sparks and ignition of flammable vapours. The pipe or nozzle of the steam supply line must be effectively bonded to the tank, but this will not prevent a charge from being generated by the steam after it leaves the nozzle or the end of the pipe. A charge may accumulate on an electrically insulated metallic object inside the tank and result in sparking when the object comes close to any part of the tank at ground potential. Steam should be dry or super heated. Wet steam should not be used as it gives high space charges and possibly water slugs which may act as insulated conductors capable of producing incondiary sparks.

Steam shall be introduced through a connection near the bottom of the tank, and the roof manway or gauge hatch shall be left open during the entire operation to avoid building excessive pressure while steaming or creating a vacuum as the tank cools. When employing steam vapour-freeing, it shall be ensured that sufficient vacuum venting is provided to prevent vacuum formation within the vessel due to rapid steam condensation.

14. TESTING FOR HYDROCARBON VAPOUR AND HYDROGEN SULPHIDE

14.1 To determine the progress of vapour-freeing operations, the atmosphere in the tank should be tested to determine the amount of hydrocarbon vapours left, and for the presence of hydrogen sulphide in tanks which contained sour stocks.

14.1.1 Tests for hydrocarbon vapours shall be made by using the appropriate combustible gas indicator, certified by the competent authority to be safe for use in such an atmosphere.

14.2 First, tests shall be made at openings where vapours are leaving the tank, keeping in mind that the concentration of vapours at the point of testing could be lower than at other points within the tank. Because of this variation in concentration, it is highly desirable that ventilation of a tank be continued until a zero reading is obtained on the indicator in such tests. The tester may then enter the tank without respiratory equipment to make further tests inside the tank. In large diameter tanks, where sufficient openings are not available to take representative tests from outside, it may be necessary for the gas tester to use air supplied respiratory protective equipment. If the tests inside the tank show the presence of vapours above 5 percent of the lower flammable limit, further vapour-freeing shall be resorted to and entry is permitted under certain conditions as below (also refer **15.2.2**):

i) For entry without respiratory protective equipment, the atmosphere within the tank shall be brought below 5 percent of the lower flammable limit.

ii) Entry with respiratory protective equipment which provides independent air supply, is permitted for cold work only, up to 20 percent of lower flammable limit. No entry shall be permitted even with respiratory protective equipment, for lower flammable limit exceeding 20 percent.

14.3 The presence of hydrogen sulphide can be detected by the way this gas blackens moistened lead acetate paper. Also, hydrogen sulphide detectors are available to test an atmosphere for this gas. The instrument shall be checked to ensure that it is functioning properly before it is used.

15. OPENING THE TANK AND REMOVAL OF SLUDGE

15.1 The tank shall be opened for the removal of sludge only after the tank has been vapour-freed. Workmen shall wear protective respiratory equipment against hydrogen sulphide gas when they work in tanks which contained sour stocks.

15.2 Sludge may be removed by various methods or by combination of methods depending upon the construction of the tank and the area and size of shell openings. Possibly, the simplest method is to sweep the sludge into piles and shovel it into buckets or wheel barrows to remove it from the tank; and wash down the tank with water-hose stream (keeping water velocity within one metre/second). If the tank has floor-level, clean-out manways, much of the sludge may be removed by flushing out the tank with water. If such openings do not exist, pumps of the self-priming type or water operated ejectors may be used with advantage.

15.2.1 While discharge of sludge and sludge-laden water into sewer system is permissible in the case of unleaded tanks, sludge or sludge-laden water in the case of leaded tanks shall not be discharged into sewers. The sludge in this case has to be removed and disposed of as prescribed in **15.2.2** and **18**.

15.2.2 For the purpose of removal of sludge, flush sludge-laden water shall be discharged through the clean out sealways into a sludge pit dug nearby. The size of the pit will be determined by the quantity of sludge in the tank. Sludge will settle at the bottom of pit and water may be allowed to run into sewer. To avoid any possible ignition due to traces of hydrocarbons in the water, additional water shall be put down stream into the sewer. If men have to enter the tank for the purpose of cleaning, the lower flammable limit shall be less than 20 percent and oxygen content more than 19·50 percent. Further they shall wear full protection, that is fresh air-hose mask, cap, light overalls (white or light coloured) clean underwear, gloves, fresh socks, rubber boots. The men shall be rotated periodically. The excess water in the pit may be drained by steam or air operated pumps.

15.3 Flammable and toxic vapours may be present so long as oil or sludge remains within the tank. For this reason it is desirable to continue forced ventilation regardless of the results of the test for petroleum vapour until all sludge has been removed and so long as men are in the tank. Tests for petroleum vapour shall be repeated before re-entry into the tank after any extended interruptions of work or after an overnight break in operations.

15.3.1 While men are cleaning the tank, they shall be under the constant observation of a competent man outside the tank.

15.4 Precautions shall be taken to ensure that the skin does not come in contact with oil. However, if such contact cannot be avoided, the oil should be washed from the skin with soap and water as quickly as possible.

15.5 To prevent spontaneous combustion, sludge removed from tanks which contained sour stocks should be kept wet until final disposal.

15.6 It is most important to check the working area thoroughly to be certain that it is impossible for flammable gas, vapour or oil to enter the area during the progress of hot work.

15.7 Flammable vapours may enter through leaks in the tank bottom or may evolve from pockets, recesses, spaces between double walls, within double bulk heads and within roof supports which may retain oil.

16. CLEANING INTERNALLY PAINTED TANKS

16.1 General

16.1.1 Storage tanks are painted internally with amine cured epoxy resin paint either to protect the surface from corrosion or to preserve the purity of the contents.

16.1.2 The surfaces of storage tanks, which are to be internally painted with amine cured epoxy resin paint, shall be cleaned by shot blasting to remove completely all rust, scale, etc. One coat of amine cured epoxy resin clear lacquer shall be applied immediately after a surface has been prepared. This shall be followed by 3 coats of this paint and finally, by the fifth coat of clear lacquer to provide a minimum of total dry film thickness of 125 microns.

16.2 While removing sludge from such tanks, care shall be taken to ensure that the painted surface is not scratched/damaged during cleaning. After cleaning, visual inspection shall be carried out. If the deteriorated areas are distributed and minor in nature, patch painting with 3 coats of amine cured epoxy resin paint may be applied. If, however the total deteriorated area exceeds 25 percent of the total surface area complete repainting of the tank shall be done.

17. CHECK LIST

17.1 A check list to ensure that a tank is safe to permit the entry of personnel for cleaning and to carry out the inspection/repair, etc is summarised in Appendix A.

SECTION III — SLUDGE DISPOSAL AND DISMANTLING/ DISPOSAL OF STEEL

18. DISPOSAL OF SLUDGE

18.1 General — The residue remaining in leaded gasoline storage tank, after all recoverable gasoline has been removed, consists of a liquid phase and a solid phase. The liquid phase is primarily water and a small quantity of hydrocarbons which readily float on top of the solids. The efficient recovery of gasoline from the storage tanks is necessary to minimize the amount of hydrocarbons contained in the liquid phase. This liquid phase can then be disposed of as waste water in a manner consistent with current water pollution regulations.

The solid phase is a mixture of insoluble deposits wetted with water and hydrocarbons containing organic lead. This mixture is referred to as sludge.

18.2 Two methods are commonly used for disposing of sludge from leaded gasoline storage tanks. They are ‘burying’ and ‘weathering’. Thermal methods are effective, but not commonly used because incineration equipment is not always available.

18.2.1 *Burying* — In this method, a pit is dug in which the sludge is dumped and then covered with 300 to 600 mm, of fresh earth. This area shall be adequately marked, so that no one inadvertently uncovers the buried sludge. Experience indicates that buried organic lead compounds decompose slowly. If a ditch or trench is dug through the sludge pit, organic lead compounds may be uncovered. Investigation of buried sludge by excavation and lead-in-air analysis of the same has shown that the organic lead content of the air above the sludge during excavations is so low that it does not constitute a significant hazard. However, if disturbance of buried sludge become necessary, protective clothing shall be worn purely as a precautionary measure, until the sludge has been relocated in a fresh burial site, or treated and disposed of as described in the weathering method given below.

18.2.2 *Weathering* — The sludge is stored in a pit in an even layer of 50 mm thick and exposed to sunny weather for 4 to 8 weeks. For final disposal it is a must to reduce the total lead percentage to below 0·5 percent. This may be achieved by intimately mixing the sludge with sand/earth in the ratio 1 : 1. After this is done, the sludge earth mix shall be buried in a pit with 600 mm cover of earth over it. The site of the pit be marked off permanently and a sign board put to indicate that sludge is buried there.

18.2.2.1 If, after the weathering period, the sludge is found to contain organic lead content of 20 ppm or less (0·002 weight percent) as determined by lead-in-soil analysis, the sludge from an orgnanic lead standpoint may then be treated as any other non-toxic industrial waste material. Signs and fences may then be removed.

19. DISMANTLING AND DISPOSAL OF STEEL FROM TANKS

19.1 If the tanks are to be dismantled and disposed of, the procedure as prescribed in **19.2** to **19.8** may be followed.

19.2 Flame-cutting or air-driven, cold-cutting tools may be used to good advantage. Tanks may be cut from the inside or outside. However, if the economics and mechanics of the situation permit, it is preferable to work from the outside of a tank to ensure clean air for personnel. Respiratory protection is required under certain conditions.

19.3 In unlined tanks, the greatest amount of lead contamination shall occur on the bottom shell ring and the bottom plates, as a result of their constant and prolonged contact with the sludge. In lined tanks, the application of heat, as from a cutting torch, may volatize toxic lead compounds absorbed in or trapped behind the lining. Therefore, precautions against breathing such vapours or fumes are of utmost importance.

19.4 The dismantling of a tank will dislodge accumulated scale and rust, resulting in abnormal amounts of dust. This is especially true during coid-cutting or sandblasting operations and is the principal reason why dismantling from the outside is more desirable. The dust may be reduced by application of water spray or fog.

19.5 In the dismantling of pontoon roofs, precautions shall be based on the assumption that leakage may have exposed the inside of the pontoons to leaded gasoline vapours.

19.6 Cold Cutting

19.6.1 If dismantling is done from inside the tank, excess scale or rust shall be removed before the cutting tool is employed.

19.6.2 During chipping and cold-cutting operations, all men within the tank shall wear approved toxic-dust respirators. These shall also be worn if dusty conditions prevail when the tank is dismantled from the outside.

19.7 Flame Cutting

19.7.1 Prior to flame-cutting operations, any loose scales in the vicinity shall be removed and an area of at least 150 mm on either side of flame-cutting site shall be thoroughly cleaned to bare metal.

19.7.2 Sand blasting or power-wire brushing are methods which will clean metal sufficiently for flame-cutting without respiratory protection.

19.7.3 Sandblasters shall wear air-supplied sandblasters' helmets. Those engaged in power-wire crushing and all other personnel in a tank while sandblasting or power-wire brushing is in progress shall wear approved toxic dust respirators.

19.7.4 To provide positive freeing of gas which may be present in pockets or depressions as a result of leaky bottoms, it may be necessary to raise, roll up, or move the bottom before it is flame-cut.

19.8 If the tank plates are to be disposed of for scrap, they may be regarded as completely safe only after heating, that is by using a flame cleaner or by removal of all scale grit or by shot blasting. If the plates are grit/shot blasted, care should be taken to collect the grit/shot from the operation to prevent the spread of lead-bearing dust. The used grit/shot shall be treated as contaminated and not re-used for other operations.

APPENDIX A

(*Clause* 17.1)

CHECK LIST FOR TANK CLEANING AND ENTRY

A-1. Has process supervisor and maintenance engineer reviewed all the probable hazards connected with tank cleaning ?

A-2. Is work permit system followed ?

A-3. Are special precautions taken for cleaning tanks that has contained leaded products ?

A-4. Is respiratory protective equipment in good condition ? Are men trained in their proper use and know their limitations ?

A-5. Are gas testing equipments in good operating conditions ?

A-6. Endeavour to completely empty out all liquid hydrocarbons from the tank through (i) feeding to unit, (ii) suction lines, (iii) water draw off, and (iv) repeated floatation of water.

A-7. Do not introduce water into tanks until temperature of oil is well below 100 °C.

A-8. In case portable transfer pump is used, follow the guidelines given below:

- i) A steam or air driven pump is preferable to an electrical one, located outside fire wall.
- ii) If electrical pump is used, follow Electrical Classification for Hazardous Areas (Refer Petroleum Rules 1976).

iii) Preferably use tested standard steel piping instead of hoses.

A-9. Have you ensured that vapour will not come in contact with ignition source, while vapour-freeing ?

A-10. Do not allow entry inside the tank until all lines are blinded.

A-11. Make effort to clean the tank from outside as far as practicable.

A-12. Do not allow entry inside the tank even with respiratory equipment, above 20 percent of lower explosive limit (lower flammability limit).

A-13. Have you kept a stand-by while men are working inside the tank ?

A-14. Have you ensured complete removal of all liquid hydrocarbons, deposits, sludge combustibles, etc. and also examined pontoons, linings, and bottoms prior to starting hot work? Have you taken combustible gas indicator readings and seen that it reads zero ?

A-15. Have you ensured that no one is left inside the tank and no material is kept inside, prior to buttoning up the tank ?

(*Continued from page* 2)

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